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5 September, 1976

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GEOLOGICAL STRUCTURE AND WATER RESOURCES IN  
CENTRAL SPAIN Quarterly Report (Instituto  
Geografico y Catastral) 51 p HC A04/MF A01

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THEMATIC MAPPING, LAND USE, GEOLOGICAL STRUCTURE AND WATER  
RESOURCES IN CENTRAL SPAIN.

ERTS

Project no.28760

Third Quarterly Report

**ORIGINAL CONTAINS  
COLOR ILLUSTRATIONS**

#### CONTRIBUTING ORGANIZATIONS

- Centro de Estudios Hidrográ-  
ficos del Ministerio de Obras  
Públicas.
- Instituto de Geografía Apli-  
cada del Consejo Superior de  
Investigaciones Científicas.
- Instituto de Edafología del  
Consejo Superior de Investi-  
gaciones Científicas.
- Cátedra de Geodinámica Interna  
de la Universidad Complutense  
de Madrid.
- Cátedra de Geografía de la Uni-  
versidad Complutense de Madrid.
- Centro de Investigación UAM-IBM  
de la Universidad Autónoma de  
Madrid.
- Instituto Geográfico y Catas-  
tral

# THEMATIC MAPPING, LAND USE, GEOLOGICAL STRUCTURE AND WATER RESOURCES IN CENTRAL SPAIN.

Project no.28760

## I. INTRODUCTION

This Third Quarterly Report is submitted as indicator of the follow-on research carried out during the project no. 28760 over Central Spain. All information received from NASA has been distributed to the participant organizations and, at the moment, every group is actively dedicated to the completion of the Final Report.

Some results are anticipated here in the fields of cartography, soil classification by computer processing, geology and forestry.

## II. TECHNIQUES

No new images have been received from NASA for development of this project, as existing LANDSAT information over Central Spain is already complete and of good quality. Some images are expected to come from the Italian receiving station of Telespazio but, because the delay on delivery, they will not be reproduced or distributed to participants in time for submission of results in the Final Report.

### Photography

Reproduction work of black and white negative transparencies in 70 mm has been finished. All received images have been enlarged at scale 1:500.000 in paper prints by the photographic laboratory of Instituto Geográfico y Catastral(IGC)

These copies were obtained on Agfa Copyline Projection P150 WP paper, in all four bands MSS, and distributed to participants in the project.

Color processing has continued during the last three months with two new techniques being evaluated:

- 1 - Enlargement from negative to positive copy at scale 1:500.000. This was done using as original negative the output product of the DICOMED D-47 film recorder, which provides a 70 mm(-) false color composite of a CCT in Kodak 4107 Vericolor II film. Enlargement was done on Kodak RC37 paper processed with 2-step Beseler chemicals. These chemicals gave excellent results and have the following characteristics as advantage from the positive-to-positive process Cibachrome evaluated in the earlier Second Quarterly Report:
  - possibility of use in drum processing with natural light
  - possibility of use at room temperature
  - low time of processing (15 minutes maximum)
  - no need of intermediate wash baths of water
  - only 2 chemicals and a final wash bath of water required
  - lower price than Cibachrome chemicals
  - durability
  - possibility of regeneration

Filter factors used generally include Magenta and Yellow filtration of light with the Cyan filter set at zero. This combination gives an excellent false color image, because the low green values obtained on the color prints and the good saturation of blues and reds. Also, this filter combination provides a correction of the greenish color obtained in the originals furnished by the DICOMED film recorder, which was not possible to be changed because the automatic processing of the negative film done by

commercial companies (ROS Fotocolor S.A. or PIX Laboratories, Madrid).

- 2 - Contact copy of three spectral bands 4, 5 and 7 in 70 mm format, with blue green and red filter, on a color positive or negative film. This technique was intended for obtaining a color composite original in 70 mm format, to be used for enlargement purposes. The result of this work was not satisfactory and no efforts have been done to continue on this line of photographic work. The main problem found was of registration of the 70 mm originals, which could not be solved.

As option, the reproduction of false color paper prints at scale 1:500.000 on negative film (70 mm) is being tested. If this technique provides good results, the enlargement of such color original at scale 1:500.000 should be tested for image quality and resolution. This is a first step for obtaining an original false color negative in 70 mms, being able to be enlarged as many times as desired for distributing color paper prints at scale 1:500.000 to the community of national users. As EROS Data Center does not provide color film in 70 mm, a full collection of LANDSAT color copies at scale 1:500.000 over Spain will be purchased in the future if this technique shows promising.

#### Computer processing

This section is not intended to give details on the computer processing techniques used by each of the participant organizations in their own scientific fields of work. Only some general remarks will be indicated concerning the main domains of research carried out in computer processing, all of them being applied by several participants. More detailed information will be given at the Final Report by each participant.

There are two important problems that have been envisaged in the last three months, both of them affecting to the participants in a common way:

- Registration of NASA CCTs to a geographical reference system
- Radiometric correction of NASA CCTs.

Registration of images for cartographic purposes posed the question of how accurately was necessary to establish the position of control points, and how precisely such position could be identified on the image.

Considering the larger working scale for topographic mapping of LANDSAT-2 data as being 1:200.000, the required geographical coordinates (longitude and latitude), were obtained from maps at scale 1:200.000; but such information could not be applied to identify the control points in the image, and data had to be extracted from maps at scale 1:50.000. Once the control points had coordinates, their identification through ERMAN-2 program (registration option), on the interactive television terminal of IBM-Scientific Center of the Autonomous University of Madrid was done via cursor with display of the image in false color at the same scale 1:50.000.

Each matrix of 1000x1000 pixels has at least 10 control points, which allowed an adjustment of coordinates by second degree polynomial algorithm. In the future, the IBM-Scientific Center will implement a registration program for application to a full 3240x2340 LANDSAT image by means of 20 control points. The software for this purpose was developed by IBM-FSD in Gaythesburg, Maryland, and it will be modified in Madrid for application to the new IBM 370/145 computer to be installed next year. This software is not intended to be operational by the end of this project, but it will be an excellent tool for positioning all LANDSAT imagery over Spain referred to UTM coordinates, as the preliminary step for execution and updating of all the topographic maps of the country at scale 1:200.000.

Radiometric corrections of NASA CCTs have been done in all the tapes received from EROS Data Center. They include expansion of radiometric values from 6 and 7 bits to 8 bits (256 intensity values). Figures 1 and 2 are a representation of the four bands corresponding to a corrected image taken over Madrid. This radiometric expansion was done for two purposes:

- digital processing of the tapes in an IBM 360/65 computer with ERMAN-2 program.
- conversion into image through a DICOMED D-47 film recorder (able to work only at 6 or 8 bits).

As the final document for cartography and other applications is an image to be photointerpreted, some contrast enhancement was necessary in the original tapes. From the cumulative curve of the histograms a conversion was done for them to have a linear distribution, which gave an equally distributed number of pixels in each interval of intensity values. As result, the corrected tapes were again reformatted and converted to false color image with the DICOMED film recorder.

#### Field work

All participants concerned with scientific research in geomorphology, land use, soils and geology have been checking their own test sites with the purpose of obtaining the necessary ground truth. Their work is part of the reports provided by each participant organization and will not be discussed in this section.

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Figure 2. Histogram of band 7 in image no. 2223-10135

VALUE	SAMPLES	NO OF SAMPLES PER * = 10000
0	23341	**
4	0	
8	0	
12	4	
16	1502	
20	5	
24	7	
28	4	
32	1502	
36	1	
40	3	
44	103	
48	3026	
52	5953	
56	22012	**
60	27126	**
64	17896	*
68	32093	***
72	77398	*****
76	66299	*****
80	88904	*****
84	92526	*****
88	31103	**
92	133186	*****
96	63123	*****
100	75960	*****
104	113585	*****
108	176799	*****
112	75650	*****
116	321604	*****
120	92024	*****
124	96724	*****
128	179121	*****
132	62351	*****
136	158104	*****
140	83168	*****
144	163837	*****
148	72093	*****
152	44114	*****
156	152053	*****
160	78920	*****
164	75141	*****
168	34385	**
172	20491	**
176	34608	**
180	31814	**
184	14712	*
188	11023	*
192	16510	*
196	9690	*
200	9811	*
204	6030	*
208	8674	*
212	2965	*
216	7059	*
220	1157	*
224	7101	*
228	2063	*
232	5858	*
236	231	*
240	4731	*
244	1710	*
248	1251	*
252	97064	*****
TOTAL = 3322992		

Figure 1. Histogram of band 4 in image no. 2223-10135

VALUE	SAMPLES	NO OF SAMPLES PER * = 10000
0	23456	**
4	0	
8	0	
12	0	
16	1500	
20	1	
24	1	
28	11	
32	1519	
36	55	
40	2689	
44	14017	*
48	15210	*
52	39268	***
56	24052	**
60	35513	***
64	76700	*****
68	20709	***
72	116793	*****
76	72944	*****
80	69715	*****
84	72245	*****
88	58703	*****
92	108295	*****
96	107711	*****
100	47313	***
104	85602	*****
108	96549	*****
112	94260	*****
116	140682	*****
120	61072	*****
124	74364	*****
128	147766	*****
132	71832	*****
136	140250	*****
140	73288	*****
144	87401	*****
148	104394	*****
152	63997	*****
156	90545	*****
160	65334	*****
164	89513	*****
168	106949	*****
172	105689	*****
176	30776	***
180	81450	*****
184	15861	*
188	50714	*****
192	20292	**
196	14330	*
200	12526	*
204	14843	*
208	5079	*
212	10256	*
216	2601	*
220	6932	*
224	7220	*
228	2649	*
232	2224	*
236	3309	*
240	1051	*
244	3049	*
248	619	*
252	85902	*****
TOTAL = 3028992		

5a



### III. SIGNIFICANT RESULTS

This section contains all the contributions from participating agencies. In some cases anticipated results have been obtained; in other cases reports are an indication of progress done in the investigation, with no anticipated results. Because the multidisciplinary character of this project, covering varied scientific fields, all contributions are presented separately.

## C A R T O G R A P H Y

### APPLICATION OF LANDSAT-2 IMAGES TO UPDATING CARTOGRAPHY AT SCALE 1:200.000.

By Germán L. Lemos and Jesús Roca Novoa  
Instituto Geográfico y Catastral  
Madrid.

#### INTRODUCTION.

Cartography at small scales is always a problem of generalization of existing information at larger scales. If this problem is contemplated from the point of view of the rapid changes occurring in the nature, it is always difficult to decide what information should be appearing on a small scale map and how to maintain such information up to date.

This report presents a method for updating cartography in operational mode at scale 1:200.000. The technique exposed is currently being applied to one of the most recent maps existing in Spain at such scale: The Provincial Map of Madrid, made in 1975 by Instituto Geografico y Catastral.

The last images obtained by LANDSAT-2 over the area show good capability for updating existing cartographic information. This is done by geometric correction of the magnetic tapes with control points of accurate geographical coordinates located in the image, and registration of LANDSAT data to UTM coordinates. Results are converted to false color images at scale 1:200.000, as the basic document for photointerpretation and updating of existing maps. A list of features to be updated is presented.

## AVAILABLE INFORMATION AND FACILITIES.

Input data to an operational cartographic system at scale 1:200.000 will be LANDSAT-2 photographic material and corresponding magnetic tapes. Information available consists in black and white negative transparencies of LANDSAT imagery in bands 4, 5, 6 and 7, as well as the corresponding magnetic tapes in 9 track, 800 bpi received from NASA upon request to the EROS Data Center.

Ancillary information is also required to be entered in the cartographic system, consisting of all available maps to scales ranging from 1:100.000 to 1:500.000. This is necessary in order to provide control points in geographical coordinates. In the case of the Central Region of Spain, the Provincial maps at scale 1:200.000 were used. As another option could be considered utilization of the existing Army Map Service Cartography at scale 1:250.000 over Spain.

Facilities required include the following equipments:

- Computer and software able to reformat NASA CCTs, interactive television terminal and a program for registration of control points.
- Conversion of results from magtape to image by means of a film recorder. In this case it was done with a DICOMED D-47 equipment operational at Instituto Geográfico y Catastral.
- Photographic laboratory for processing and enlargement of output images at scale 1:200.000. Enlargement of input 70 mms transparencies at scale 1:500.000 is also necessary for location of control points and their identification on a map by geographical coordinates at scale 1:200.000 or 1:250.000.
- Photointerpretation facilities. Required equipment could be one of the followings:

- \* a Zoom Transfer Scope
- \* an optical pantograph
- \* a color composite viewer

All of them are available at Instituto Geográfico y Catastral. From an operational point of view better results could be achieved with the optical pantograph, which allows a fast work by simultaneous projection of the map and the image.

#### OPERATIONAL METHODOLOGY.

Updating cartography at scale 1:200.000 requires a methodology of work based on two aspects:

- cartographic accuracy of the satellite images enlarged at that scale.
- photointerpretation of the images and their correlation to maps to be updated.

Cartographic accuracy is achieved by geometric correction of NASA CCT obtaining an output tape registered to UTM coordinates. In the case of the Central Region of Spain this was possible with image-tape no.2187-10135.

Three simultaneous operations have been done:

- 1 - Change of NASA CCT format, made compatible to the IBM 360/65 computer operational at the IBM Scientific Center of the Autonomous University of Madrid. Selection of squared subscenes of 1000 x 1000 pixels over Madrid to be registered, and display through RAMTEK interactive television terminal at approximative scale 1:50.000 in false color.
- 2 - Photographic enlargement of 70 mms transparencies of image no.2187-10135 (scale 1:3.369.000) to black and white paper prints at scale 1:500.000. Location of control points in the enlarged print. Each subscene of 1000 x 1000 pixels

above mentioned requires 8 control points for registration by a Second order polynomial adjustment. Control points must be very clearly identified at the 1:500.000 image. Good points are intersections of roads or rivers, visible geodetic points, corners of reservoirs or man-made public works. Also, control points must be clearly identified in the existing cartography at scale 1:200.000 or 1:250.000.

- 3 - Assignment of geographical coordinates to the control points, once located on the map of Madrid Province at the above mentioned scale. Longitude and latitude of such points is an input data for registration of the subscenes selected in step 1.

The next operation should be locating the control points at the screen of the subscene display and manually introducing their coordinates to the computer via cursor and terminal console. Once the operation is finished, through ERMAN-2 program, registration subroutine, the computer provides with registered subscenes of 1000 x 1000 pixels in UTM coordinates. Each pixel at this moment represents a square area of 80 x 80 m. After registering each subscene with at least 8 control points, the result is converted to tape, one for each subscene and all subscenes covering in mosaic, with 10% overlap, the area to be mapped (in this case, the Province of Madrid).

Before converting output tapes to images some radiometric corrections are introduced by equalization of histograms in bands 4, 5 and 7. The results are reformatted to be compatible with the DICOMED D.47 and the tapes sent to Instituto Geográfico y Catastral. See figure 1.

The DICOMED D-47 is run at low resolution providing false color images in 70 mm format, one for each tape, representing

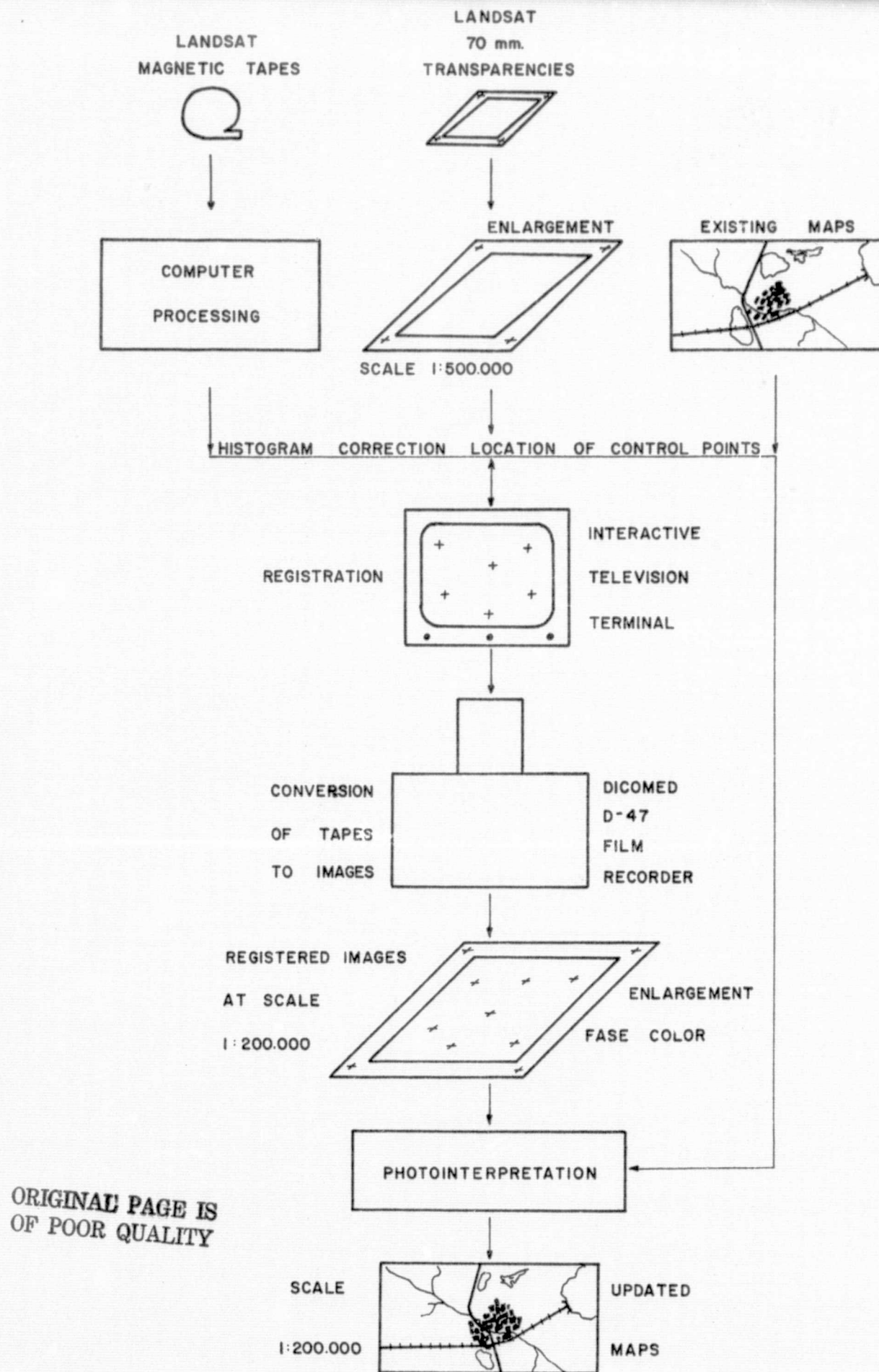


FIGURE 1. OPERATIONAL METHODOLOGY FOR UPDATING CARTOGRAPHY  
AT SCALE 1:200,000

the digital information at 256 levels in a matrix of 4000x4000 points. At the moment, each tape is converted to:

- Color negative film Vericolor II 4107
- Color positive film Ektachrome 6115

Enlargement of both originals is being evaluated with the following techniques:

- Negative to positive on Kodak color paper RC37 and 2 step Besseler chemicals.
- Positive to positive on Cibachrome color paper and P-18 chemicals.

At the moment no anticipated results can be established on which one of both method is better for operational purposes. The result is a color image in 40x50 format at scale 1:200.000.

The next step is photointerpretation of enlarged color images and updating existing maps from the data obtained. If the Zoom Transfer Scope is used some problems will appear because the limited field of view of this equipment, which forces a continuous adjustement of the map to the image, which means introducing errors in the cartographic accuracy.

As another option the Additive color composite viewer could be used, enlarging on 50x50 cms screen the originals obtained from the DICOMED. Working scale could be 1:200.000 but some parallax errors should be introduced because the focus adjustement on the upper part of the screen and drawing errors due to the transparency material used over the screen for photointerpretation. The best technique should be the use of an optical pantograph.

Photointerpretation of the resulting images is an easy and fast method for updating cartography at scale 1:200.000 in cases stated on table 1.

MAN MADE WORKS	WATER	VEGETATION	SOILS
Highways	Coast profiles	Fertile lowlands	Sand dunes
Urban Areas	Reservoirs	Forests	Volcanic areas
Airports	Rivers	Parks	Stone pits
Ports	Drainage pattern	Rangelands	Bare soils
Excavations	Tidelands		
Industrial plants	Snow (permanent)		
	Icelands		

TABLE 1. ITEMS TO BE UPDATED FROM LANDSAT-2 IMAGES FOR CARTOGRAPHY AT SCALE 1:200.000



Attention has to be called to the important point that most of such items are fast changing and their present status is what must be recorded in a good updated map.

#### CARTOGRAPHIC ACCURACY.

The mosaic of false color images at scale 1:200.000 geometrically corrected represents an area covering all the Provincial Map to be updated. As each image represents an area of 80x80 kms, errors introduced in the orthogonal projection of the map can be forgotten if the cartographic projection of the MSS images (Spatial Transverse Mercator) is considered as orthogonal.

Another point to consider is the Earth curvature, which represents in a full image of 185x185 kms a value of  $2^g 60^m$  along the 260 kms of diagonal side. If the image is considered as a photomap the error introduced is minor than the tolerance of the Provincial Map at scale 1:200.000.

Considering a mean radius for the Earth sphere of 6.370 kms, if the cord is taken in substitute of the arc distance along the diagonal of 260 kms, the central angle is  $2^g 59^m 85^s$ . The cord should be:

$$C = 2 R \sin \frac{\alpha}{2} = 259,985 \text{ kms.}$$

$$\text{and } \Delta = \text{arc} - \text{cord} = 15 \text{ m}$$

As tolerance at scale 1:200.000 is:

$$t = 0,2 \text{ mm} \times 200.000 = 40 \text{ m}$$

the earth curvature at scale 1:200.000 has not to be considered. Furthermore, as the mosaic of images obtained for photointerpretation has each subscene representing 80x80 kms, the error of substituting arc by cord is even reduced and becomes much smaller than the tolerance of the map at scale 1:200.000.

## CONCLUSIONS.

It has been established a method for a rapid updating of cartography at scale 1:200.000. Items to be updated do not appear usually in the existing maps and, what it is more important, LANDSAT-2 is providing the possibility of a periodic revision of the existing territorial information several times at the year.

The problem of generalization of information from scales 1:50.000, in order to obtain a map at scale 1:200.000 by conventional techniques, can be envisaged from a new point of view because the data provided by LANDSAT-2. This means that the satellite gives an overview of "what it is on the earth surface", and that is the information that should appear on the map, no matter how conventional techniques provided years before a symbolic representation of our planet.

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## F O R E S T R Y

### APPLICATION OF LANDSAT-2 DATA TO UPDATING FORESTRY MAPS IN THE CENTRAL REGION OF SPAIN.

By Joaquín D'Aubarede and Pilar Avizanda  
Instituto Geográfico y Catastral  
Madrid.

#### INTRODUCTION.

Multispectral information provided by LANDSAT-1 & 2 is a new tool for updating existing cartography of forests at scale 1:400.000. Such maps in the Central Region of Spain are 10 years old and because the impact caused by a growing city like Madrid in the environment, a rapid change of forest masses has to be represented in the maps.

Techniques used are photointerpretation and computer processing of LANDSAT information.

The area under study is at 100 kms. distance of Madrid and a good photographic coverage exists with high quality satellite images of less than 30% cloud cover. It is an area of easy access for taking ground truth.

#### OBJECTIVES.

It is intended to update the existing map of Vegetation in Central Spain at scale 1:400.000. This map is of very good quality but in 10 years a rapid change of forest masses occurred and it has to be corrected in forest families and, in some cases, species. Two approaches are considered:

- 1 - Photointerpretation techniques. The best image over the area supplied by NASA was LANDSAT-2 E-2170-10204. Negatives

in bands 4, 5, 6 and 7 in 70 mm transparencies were processed and contact copies in positive film were obtained with density correction. Bands 4, 5 and 7 have been introduced in the DOT Color composite viewer for photointerpretation at scale 1:500.000.

- 2 - Computer processing at the IBM Scientific Center of the Autonomous University of Madrid was done with an IBM 360/65 machine interfaced to an interactive television terminal RAMTEK. A supervised classification will be possible with the pattern recognition capability of ERMAN-2 program.

#### METHODOLOGY.

Photointerpretation with the color composite viewer showed good possibilities for delineating boundaries between forest masses. Dominant families were conifers with several species represented. Attention was given to the fact that mixed vegetation appears with coniferous trees. In general it is possible to locate such mixed forests but identification of species is not possible with the color composite viewer exclusively.

With the help of the vegetation map at scale 1:400.000, boundaries of coniferous trees have been identified along the Sierra de Gredos region, Southwest of Madrid. Such Boundaries have been drawn with black ink on a transparency located over the color composite viewer. As the viewer has horizontal screen, it was easily delineated the contour of such forests. Figures 1 and 2 represent photographs of the transparent overlay placed over the 50x50 cms screen of the DOT viewer. By different color combination of filters, the coniferous forests were easily identified.

Computer processing was done on the tape no.E-2170-10204. Three training fields were selected, two of them representing



Figure 1. Bands 4, 5, and 7 of a LANDSAT-2 image combined through the DOT viewer. Coniferous forests of Sierra de Gredos are delineated.

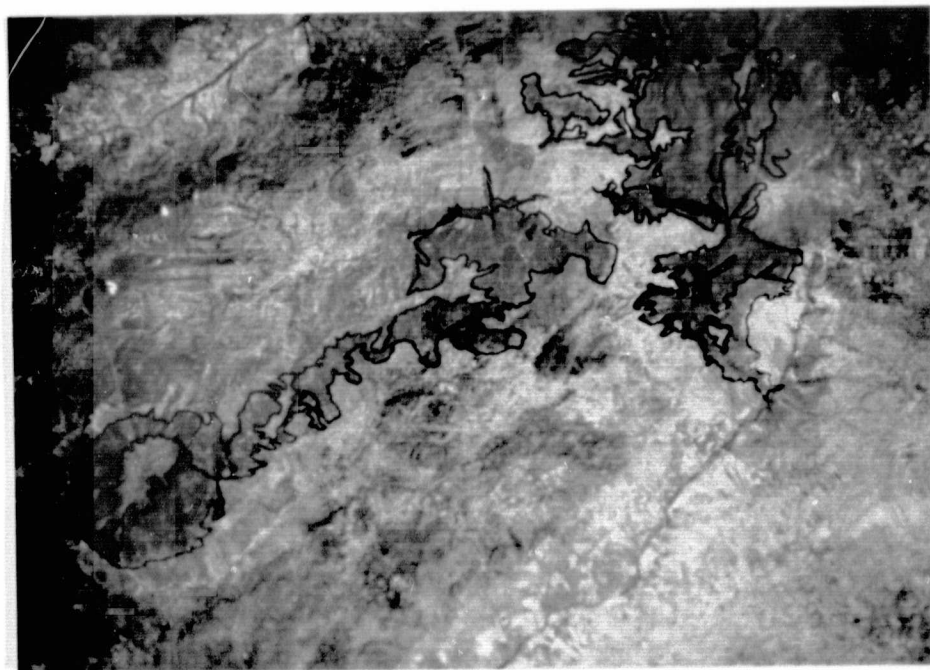


Figure 2. The same image with different color combinations. Information has been enhanced allowing better identification of coniferous forests.

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Pinus Pinaster sol. and the third a mixed forest with Quercus trees. Such fields were called: Conif, Conifi and Solano respectively. Figure 3 represents the menu of mean and standard Deviation for each class in all four bands MSS.

ERMAN-2 program has also provided the reflectance curves of each class in bands 4, 5, 6 and 7 (Figures 4, 5, 6 and 7). It can be established as anticipated result that bands 5 and 6 provide the best separability of classes between coniferous species in the Central Region of Spain.

PR 02	MEANSTD 0006	17/26/36 1	PAGE 01	OF 01
MEAN AND STANDARD DEVIATION REPORT FOR CLASSES AND TRAINING FIELDS AND ALL AVAILABLE CHANNELS				
CHANNEL NUMBER	FIELD CONIF ( 936)	FIELD CONIFI ( 714)	FIELD SOLANO ( 361)	
	CLASS CON	CLASS COI	CLASS SOLA	
	MEAN ST DEV	MEAN ST DEV	MEAN ST DEV	
1	16.57 1.54	18.38 1.92	21.90	2.38
2	10.56 2.34	13.54 3.04	19.99	3.66
3	18.11 4.15	25.14 4.32	28.21	4.59
4	10.01 2.69	14.71 2.76	16.20	2.91

Figure 3. Mean and Standard deviation of Training fields in all four bands MSS. E-2170-10204.

PR 02.HSTOGRAM 0008

\* 17/27/17 1

PAGE 01 OF 04

## HISTOGRAMS FOR FIELDS AND/OR CLASSES

CONIF ( 936)

CONIFI ( 714)

SOLANO ( 361)

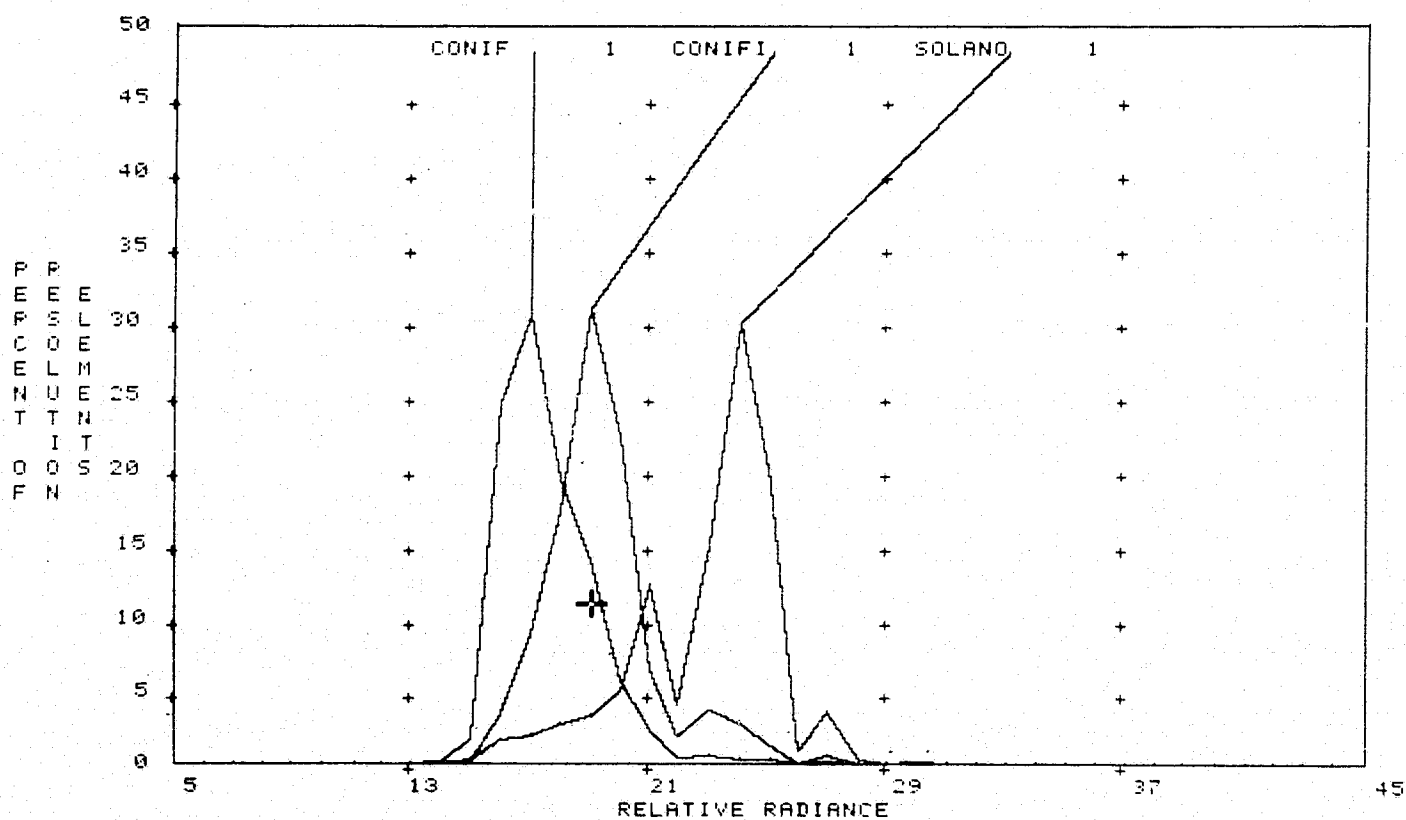


Figure 4. Histogram of training fields in band 4

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PAGE 02 OF 04

HISTOGRAMS FOR FIELDS AND/OR CLASSES

CONIF ( 9361

CONIFI ( 7141

SOLANO ( 3611

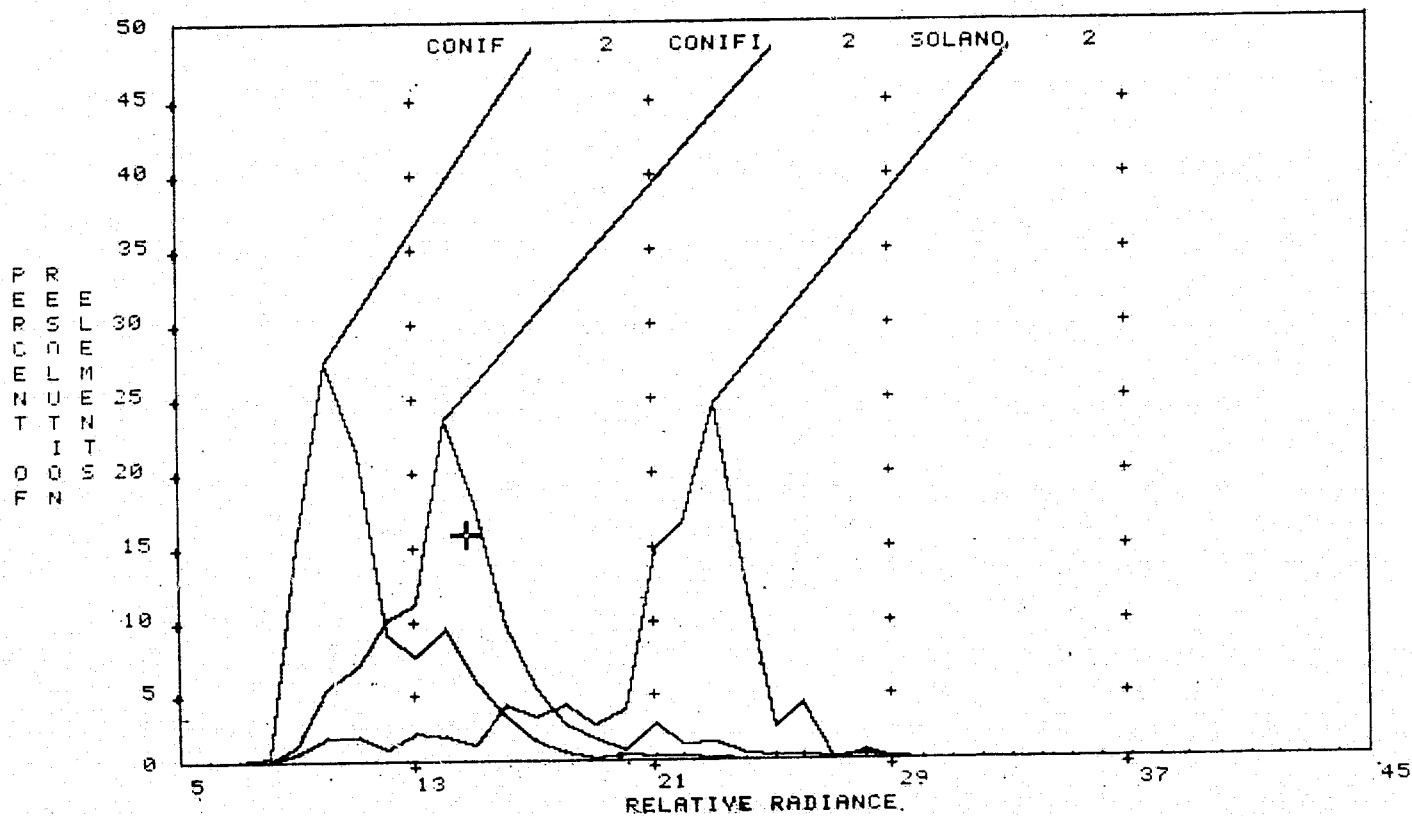


Figure 5. Histogram of training fields in band 5

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## HISTOGRAMS FOR FIELDS AND/OR CLASSES

CONIF ( 936)

CONIF ( 714)

SOLANO 3611

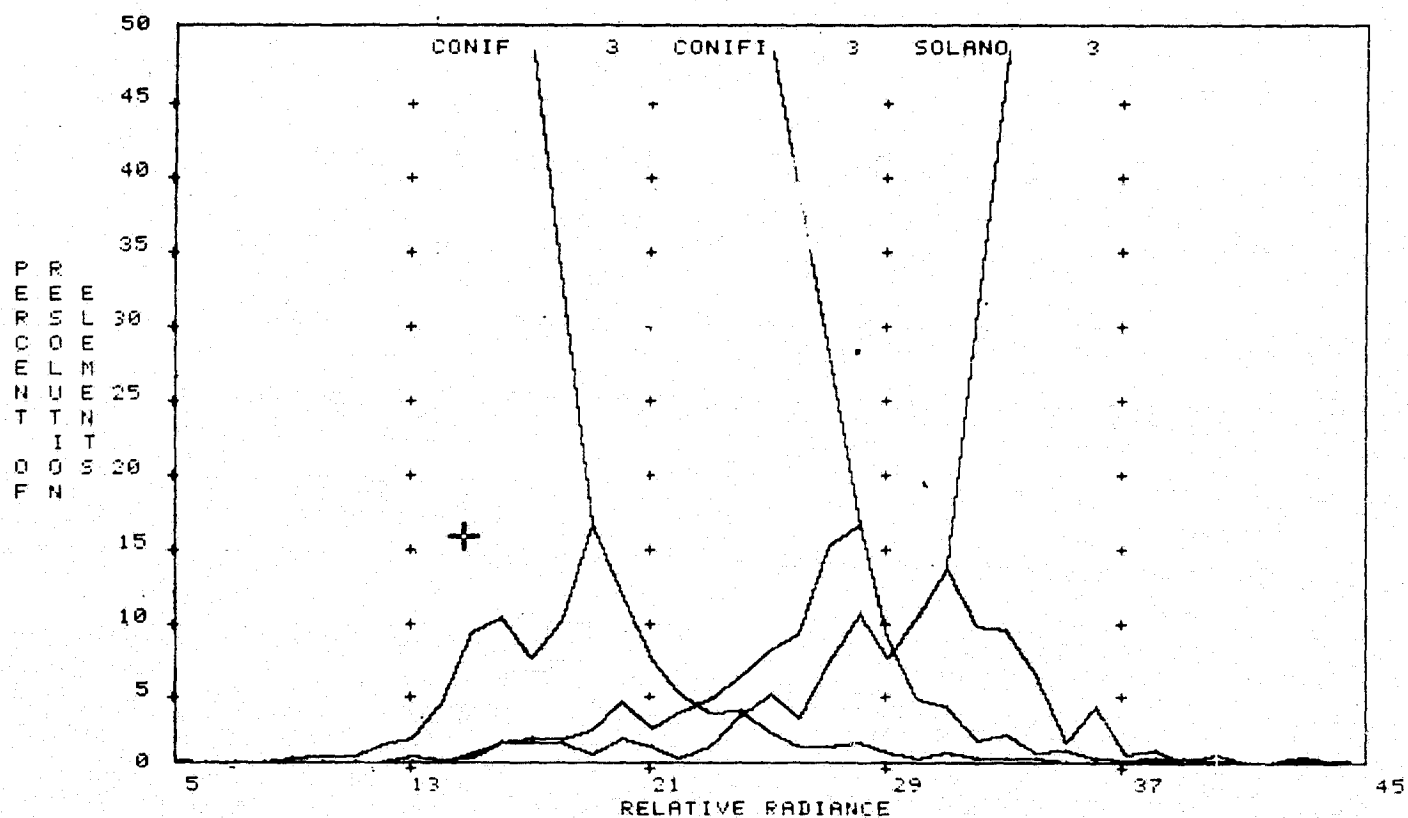


Figure 6. Histogram of training fields in band 6

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\* 17 29 36 1

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HISTOGRAMS FOR FIELDS AND OR CLASSES

CONIF : 9361

CONIF1 : 7141

SOLANO : 3611

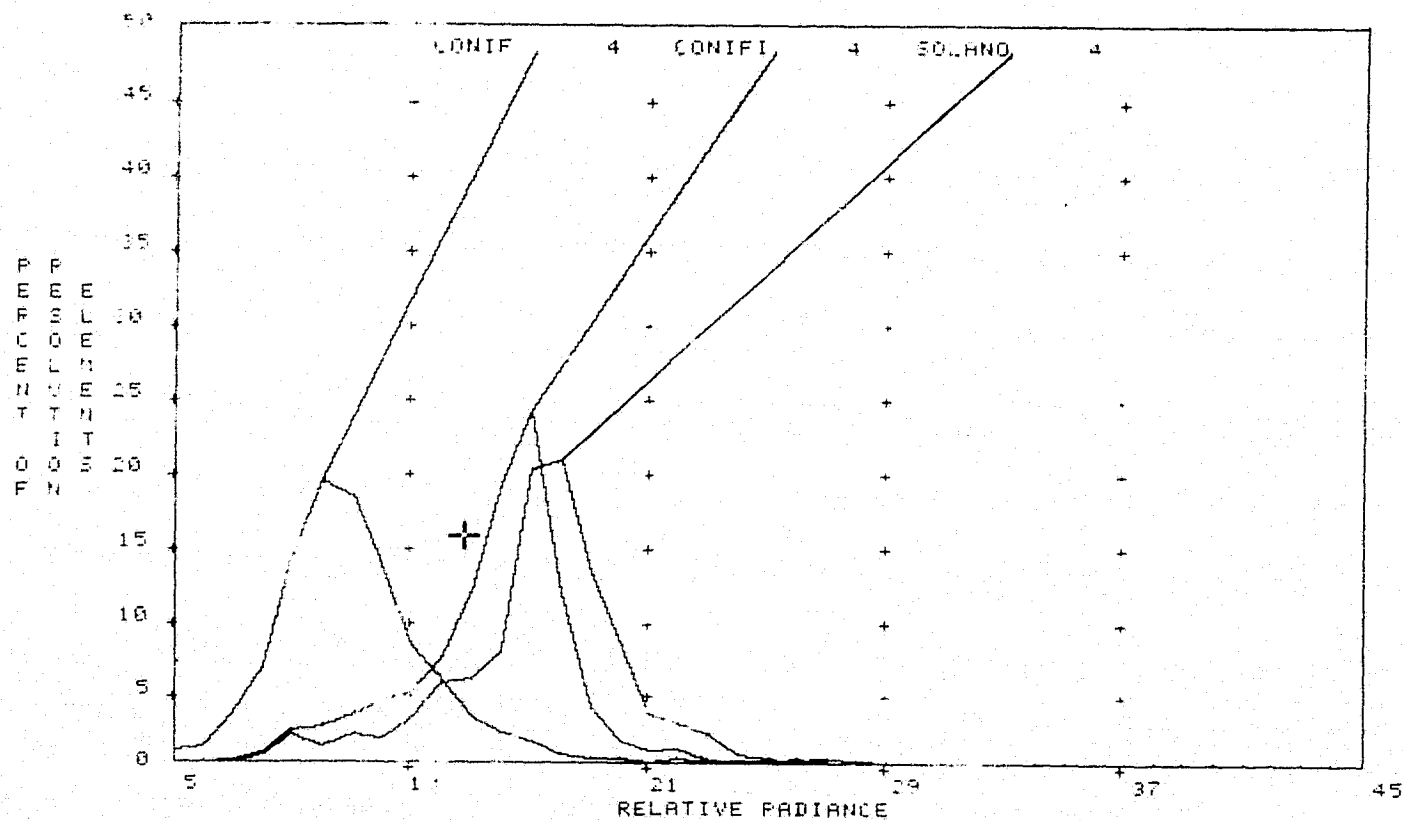


Figure 7. Histogram of training fields in band 7

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## LAND - USE/SOILS

### MULTISPECTRAL ANALYSIS OF THREE TEST SITES IN CENTRAL REGION OF SPAIN.

By José L. Labrandero  
Instituto de Edafología. Dpt. de Suelos  
Consejo Superior de Investigaciones Científicas  
Madrid.

#### INTRODUCTION.

Three test sites in the province of Madrid, representing soils, water, vegetation and urbanism, have been investigated in order to know spectral values, possibilities of identification and selection of a number of clusters ideal for each coverage of the surface.

Each one of the test sites contains 3721 pixels (61 lines x 61 Columns), equivalent to an extension of 1681 hectares. Twelve classes of cluster and eight classes of cluster were chosen as variables, looking for a higher accuracy in the final classification.

#### MATERIAL AND METHODS.

Digital analysis of the areas of Retiro, Jarama-Henares and El Pardo was done on image no.2187-10143 obtained by LANDSAT-2 in July 28, 1975. All three test sites are located around the city of Madrid.

Ancillary information used as reference for identification of spectral classes was: 1) Topographic maps at scales 1:50.000 and 1:25.000 made by Instituto Geográfico y Catastral and Servicio Geográfico del Ejército. 2) Urban maps of Madrid streets updated (for Retiro test site). 3) Soil maps at scale 1:1.000.000 and 1:100.000. 4) Aerial images in panchromatic at scale 1:25.000 taken in July 1972.

The method used in multispectral analysis is the operational at the Laboratory of Remote Sensing-LARS/Purdue University. Data taken by the MSS sensor were classified by clustering in 12 and 8 different classes. Once the function SEPARABILITY was obtained, each class was selected applying a separability not higher than 1700. After identification of each spectral class and correlation of spectral class-kind of information, values of separability were obtained for each final combined class.

#### RESULTS AND DISCUSSION.

As results of this multispectral analysis, figure 1 is presented with two dimensional diagrams (bands 5 and 6) of each spectral class.

In the area of Madrid-Retiro, three urban classes were obtained: parks, trees-greenland and bare soils. Logically, results change with eight classes of cluster and only two classes of urban land-use can be identified: groups of parks and trees, and bare soils (tables 1 and 2).

The test site of Jarama-Henares, representing a rural area, allowed verification of existing contrasts between cultivated and not cultivated soils, defining three categories of soils, three categories of crops-vegetation and two spectral classes indicating a high content of water. The reduction in the number of clusters originated a grouping of classes of soils and spectral classes very influenced by the water, remaining, however, the same number of spectral classes of crops-vegetation.

Results of the classification in the area of El Pardo were distributed in four types of soils, three types of vegetation and two types of water bodies.

This multispectral analysis allowed obtaining some technical and analytic consequences which could be valuable

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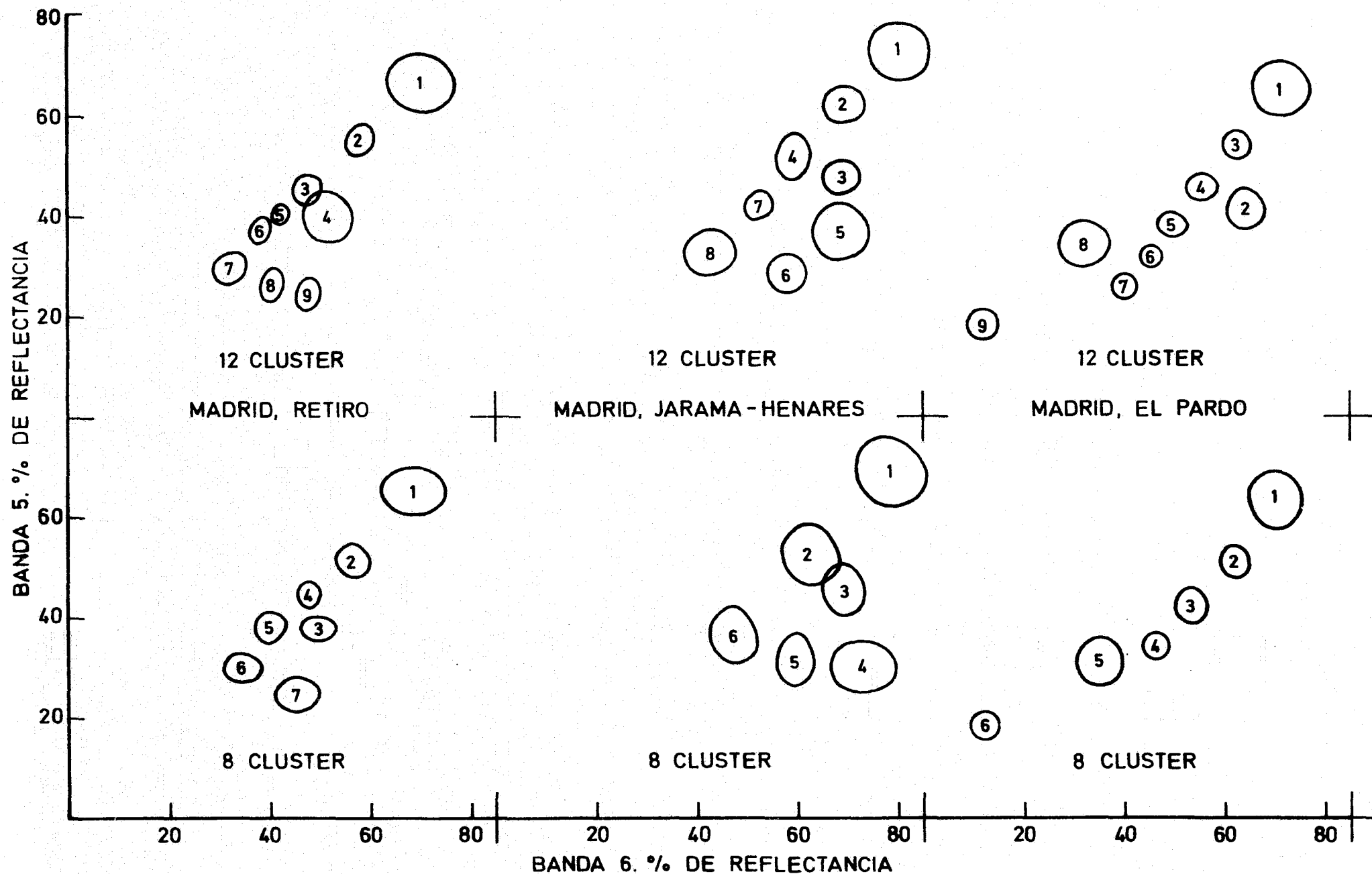


Fig. 1.- Clasificación espectral de tres áreas en la región centro

at the time of a digital classification of larger areas with similar surface cover.

As objective could be established to define the optimum number of clusters for classifying the Central Region of Spain, looking for a higher accuracy in the results and considering that more clusters should represent more computer time and a higher cost.

If the number of points assigned to a spectral class is very low it can be observed the high value of the variance in all four bands. If the values of standard deviation in the cluster classes are very high, this could represent a lower number of classes than necessary for a good classification.

In general words, items like building height, density of construction and density of population can be correlated to the spectral characteristics. Much more difficult could be correlation of ancientry of buildings with their aspect based on spectral values.

Formation of a soil map is possible by analysis and classification of LANDSAT data. The scale and number of clusters is related. At scales of 1:100.000 and smaller, representing associations of soils, it could be possible to distribute all spectral data between 8 and 12 classes.

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TABLE 1.- CLASSIFICATION OBTAINED FROM 12 CLASSES OF CLUSTER

<u>MADRID - RETIRO</u>		<u>MADRID - JARAMA - HENARES</u>		<u>MADRID - EL PARDO</u>	
<u>spectral classes</u>	<u>Significance</u>	<u>spectral classes</u>	<u>Significance</u>	<u>spectral classes</u>	<u>Significance</u>
1	Parking	1	Soil 1	1	Soil 1
2	No building 1	2	Soil 2	2	Vegetation 1
3	Urban 1	3	Crop/Veget. 1	3	Soil 2
4	No buildings 2	4	Soil 3	4	Soil 3
5	Urban 2	5	Crop/Veget. 2	5	Soil 4
6	Urban 3	6	Crop/Veget. 3	6	Vegetation 2
7	Streets/water	7	Alluvial area	7	Vegetation 3
8	Greenland/trees	8	Flooded area	8	Reservoir boundary
9	Parks			9	Water

TABLE 2. CLASSIFICATION OBTAINED FROM 8 CLASSES OF CLUSTER

<u>MADRID - RETIRO</u>		<u>MADRID - JARAMA - HENARES</u>		<u>MADRID - EL PARDO</u>	
<u>spectral classes</u>	<u>Significance</u>	<u>spectral classes</u>	<u>Significance</u>	<u>spectral classes</u>	<u>Significance</u>
1	Parking	1	Soil 1	1	Soil 1
2	No buildings	2	Soil 2	2	Soil 2
3	Greenland/trees	3	Crops/Veget. 1	3	Soil 3
4	Urban 1	4	Crops/Veget. 2	4	Vegetation
5	Urban 2	5	Crops/Veget. 3	5	Reservoir boundary
6	Streets/water	6	Flooded area	6	Water
7	Parks				



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G E O L O G Y

AN ANNULAR STRUCTURAL COMPLEX NORTH OF MADRID DETECTED BY  
LANDSAT IMAGES.

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Spain.

INTRODUCTION.

For years now the geology of the zones adjacent to Madrid have been studied, the areas occupied by Neogene sediments (mainly of Miocene), where the city itself is settled, as well as the prolongation and relation of them with the Hercynian chrystaline unit called the Central System, which is the Northern limit of the mentioned sediments.

These Neogene deposits which make up the Madrid Basin make contact with the veined chrystaline basement of the Central System (which in this zone is represented by the Guadarrama Range) by means of faults, generally inverted (BENAYAS & PEREZ MATEOS & RIBA, 1960) with a large angle (SAN MIGUEL & FUSTER & DE PEDRO, 1956) corresponding to a tectonic phase which comes after the upper Miocene but before the Pliocene.

In the septentrional zone of Madrid this contact is complicated by the existence of deposits which are Cretaceous and Paleogenes, both crumpled together by one of the anterior Alpine phases, which was at least before the middle Miocene and after the upper-middle Oligocene (FUSTER & FEBREL, 1959; DE LA CONCHA, 1962).

The alpine deformations produced folds in the limestone (Fig.4,c) evaporitic and molassic materials of the Cretaceous, lower Paleogene and upper Paleogene respectively, which show

that they have a common and predominant direction in their axial plans of NE-SW, that is parallel or sub-parallel to the mechanical contact between the Hercynian chrystalline basement and the Miocene deposits (SAN MIGUEL & FUSTER & DE PEDRO, 1956; FUSTER & FEBREL, 1959; DE LA CONCHA, 1962; DE LA CONCHA, 1963).

To try to establish the relation between the main alignments detected by geophysical methods in the Madrid Basin (CADAVID COMIÑA, 1973; HERNANDEZ FERNANDEZ, 1974) and the alignments observed in some areas of said Basin (MARTIN ESCORZA & HERNANDEZ ENRILE, 1972; MARTIN ESCORZA & CARBO & G.UBANELL, 1973) we have finished a study in which lineal accidents (very probably fractures) of the basement have been detected which were shown to be active during the Miocene sedimentation (MARTIN ESCORZA, 1976) and we also know others which were active during the Pliocene sedimentation.

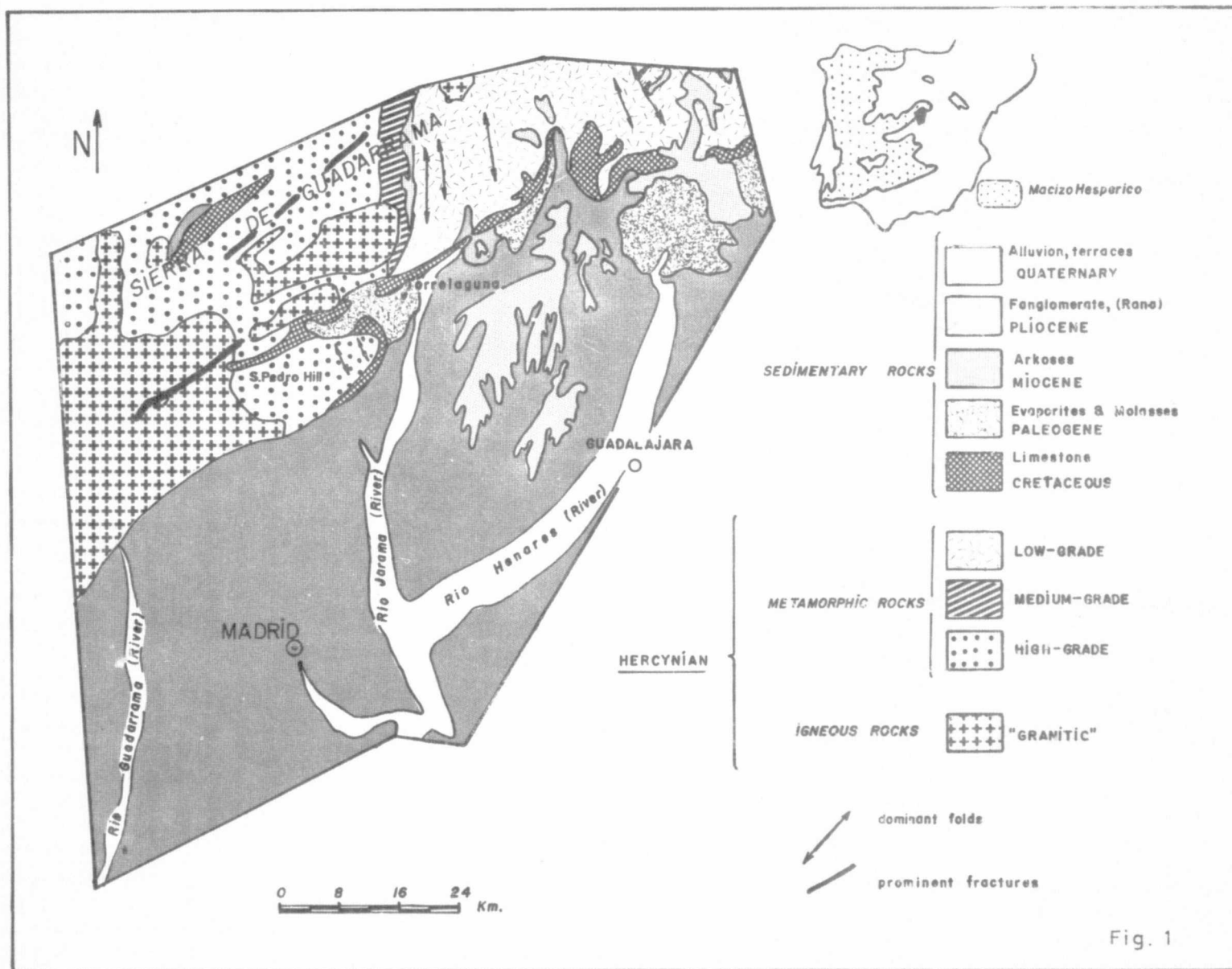
This geological framing of the zone is diagrammed in figure 1.

#### OBSERVATIONS.

Other authors before and those mentioned above knew well the septentrional areas of Madrid, and the author of this article even recognized them from different images proportioned by NASA through of the Spanish Geographical and Cadastral Institute, such as LANDSAT E-2223-10135-6; 2187-10143-5; 2187-10143-6; 2187-10143-4; 2169-10145-4; 2223-10135-7; 2169-10145-6; 2169-10145-5; 2187-10143-7; 2169-101145-7.

Well, in no case was it possible, given the scale of field study and the lack of sharpness of the ERTS images mentioned above, to differentiate clearly certain circular alignments clearly concentric which have been possible to detect in the LANDSAT images E-2367-10122-5; 2367-10122-4; 2367-10122-6

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and fundamentally in the 2367-10122-7, which has recently been supplied to us by NASA through the Spanish Geographical and Cadastral Institute and which were obtained in January 1976.

The region studied is marked in figure 2 and occupies in an approximate form that of the geological diagram offered in figure 1.

In figure 3 the concentric alignments are indicated with thicker traits than we observed in the area occupied by the section of the image represented in figure 2.

Circular structures have been pointed out over others (in finer traits) which, although without a doubt offer great interest and are easily recognized in the image, do not form part of the series of concentric circular alignments which we are dealing with in this work.

These curved lines affect, as can be deduced from observing the geological map (fig. 1) the metamorphic Hercynian material as well as fundamentally arcose deposits of Miocene, apart from the crumpled layers of Cretaceous and Paleogene; on the other hand they are shown to be evidently independent of the alpine structural directions which affect the latter. Neither are they, as can be seen in figure 1, coinciding nor adjusting to the main axis of Hercynian folding in the points where these are known.

These lines in the oriental areas of the zone have been identified by us the topographical maps (fig. 5) as corresponding to small riverbeds where surface water does not normally circulate. A good example of this is offered by the Quemadas Stream (fig. 4-D) which passes through the town of Cobena and which curves into the Valdelandina stream concentrically right to the South of the Fuente del Saz.

Also forming part of this secondary fluvial network defined by the cited lines is the stream of the Zarzuela, to

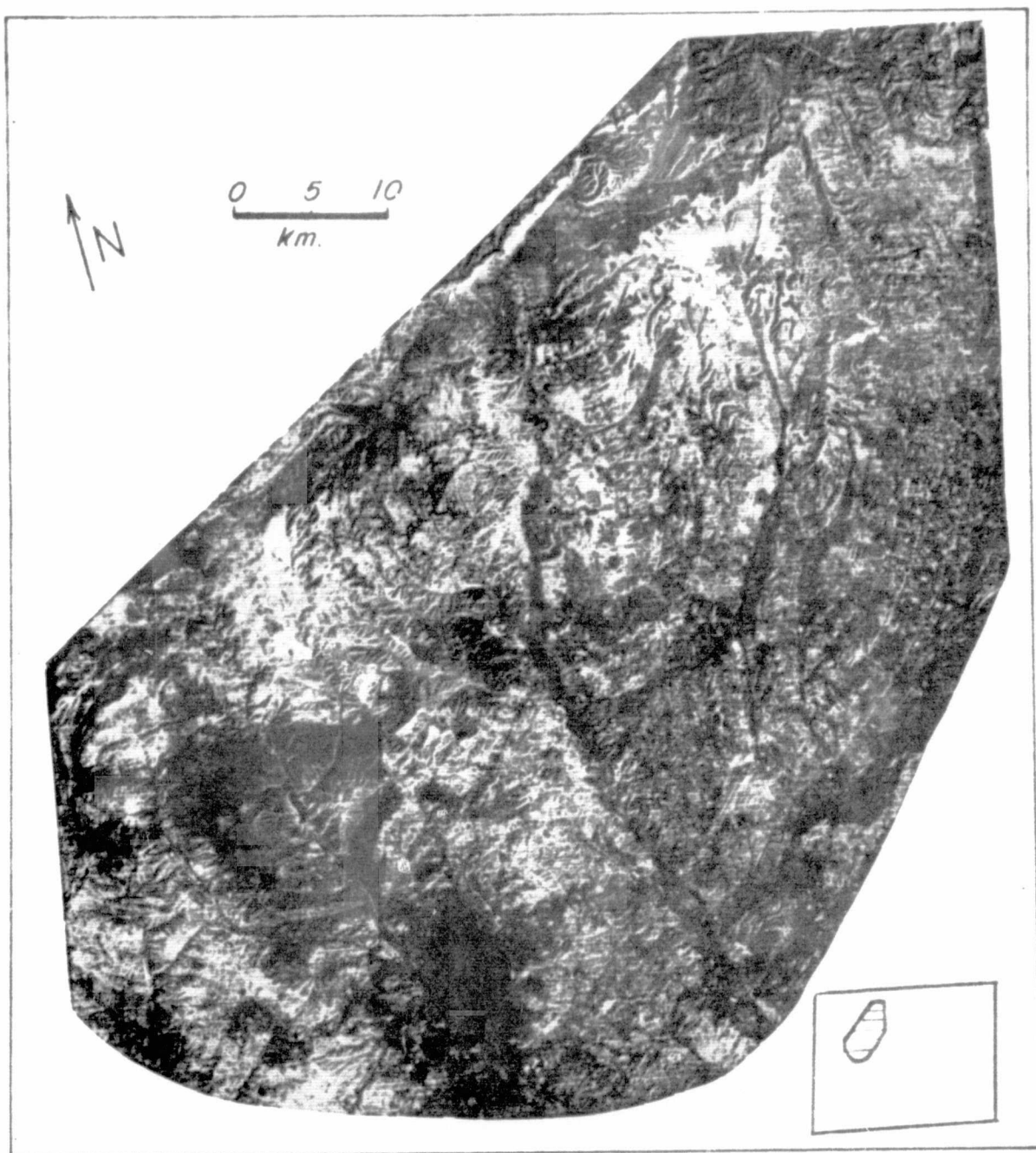
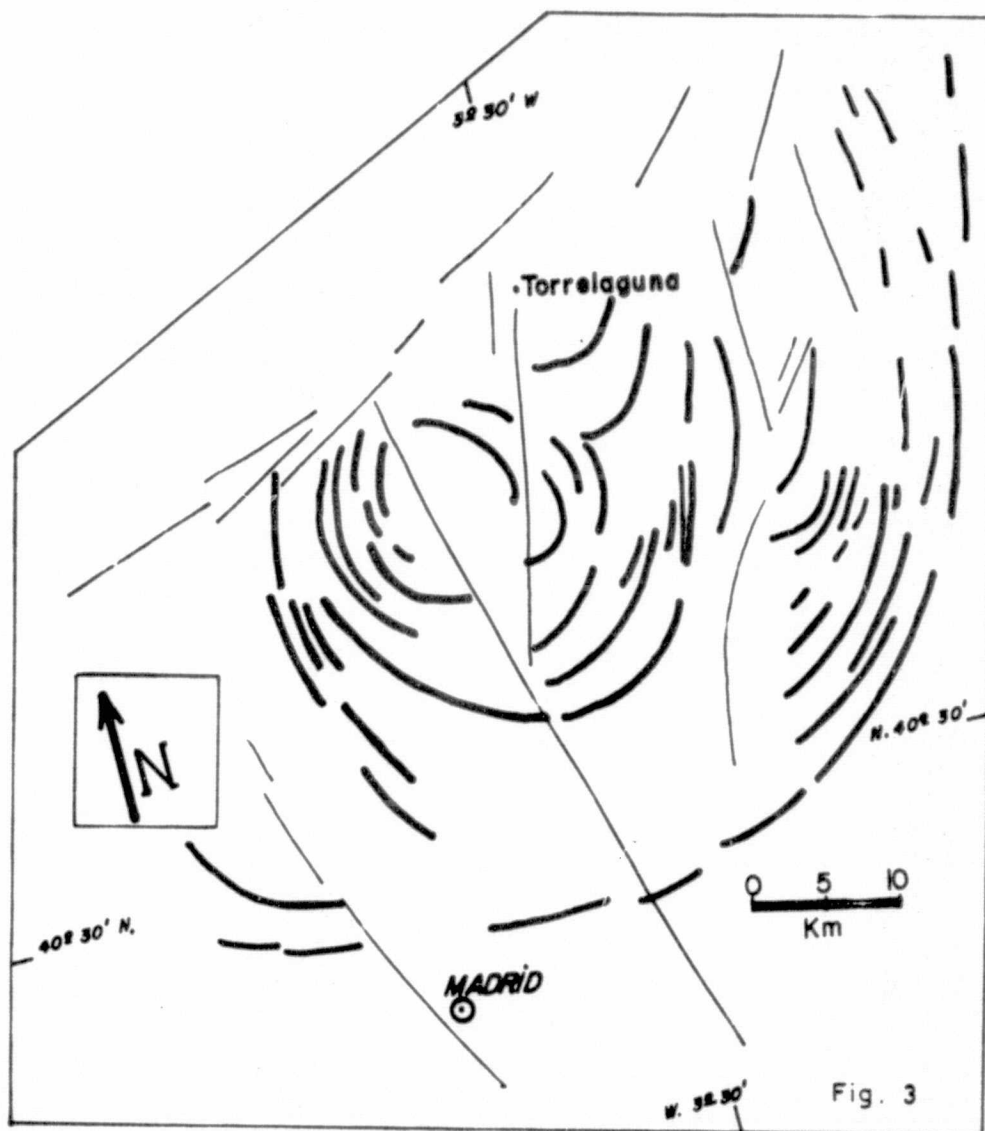


FIG. 2

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the North of Madrid, which nevertheless has a line with less curvature and thus belongs to a circle with more radius than that mentioned above. With the same characteristics, we have the Baldebeba stream, etc... (fig. 5).

On a greater scale these structures also show themselves to be curved and concentric; and in this way using the cartography at scale of 1/50.000 the significance of these lines can be even more improved. So that, as can be seen in figure 6, the stream of Quemadas is prolonged closing the curvature of the line defining it, toward the NW tending to join with the Viñuelas stream and the Moralejo stream.

It is clear that the main fluvial network of the zone formed by the Manzanares, Jarama and Henares rivers as well as by the Tozote stream do not adjust nor indicate these curved lines (fig. 5).

Also, the important metamorphic landmass dominated by the Cerro San Pedro is affected by these concentric structures as can be clearly seen in figure 2. In this landmass certain fracturation directions were earlier noted (FUSTER & FEBREL, 1958) which could belong to this circular structure, but they were then hidden by other systems of fractures and dikes existing in the zone, as well as by the lack of availability of the general vision which is offered to us by the images transmitted by LANDSAT. Nevertheless, and after seeing these images, we made a rapid and recent visit to this site and we have been able to declare that these circular lines are visible right there, in the field, and although we are not trying to get deep into these theme at this moment, we can nevertheless inform in this work that these lines correspond to fractures which affect the metamorphic materials (fig. 4-A, and 4-B) and which are presently indicated by a differential erosion at the summits (fig. 4-A) and by a fluvial encasement in the piedmont areas (figure 4-B) making up excavated lines which run following the curved directions which we have indicated.

#### DESCRIPTION AND DENOMINATION.

The circular structure with curved concentric lines which we have detected North of Madrid has approximately 30 to 40 km. radius. The amplitude seems to be greater or better represented in the northoriental areas. This structure is not complete as it is stunted by the tectonic structure of a greater order which limits the meridional edge of the Central System and which is a fracture with a NE-SWdirection which does not permit the total closing of the circle toward the North.

The center of this circular structure is found near Guadalix de la Sierra, a small village which is growing with the modern buildings of the inhabitants of the capital of Madrid who go there for vacations and weekends.

Thus, for said structure we propose the name of "Structural Halo of Guadalix".

#### SIGNIFICANCE AND ORIGIN-DISCUSSION.

It is not our main objective in this article to arrive at a tight interpretation of the "Structural halo of Guadalix" since we believe that we lack numerous field data which we must know and integrate, and a detailed support of geophysical data, all of which we shall have in the near future. In this work we are only fundamentally trying to point out the existence of this structure which has been detected using the LANDSAT images; we shall also establish a first working hypothesis on its origin.

Undoubtedly this structure, which reaches Madrid capital in its maximum radius and which affects a great area in industrial and social expansion, has a special significance with reference to foreseen practical applications which could be made by considering it interesting at the moment to look for hydrological resources fundamentally, among others.



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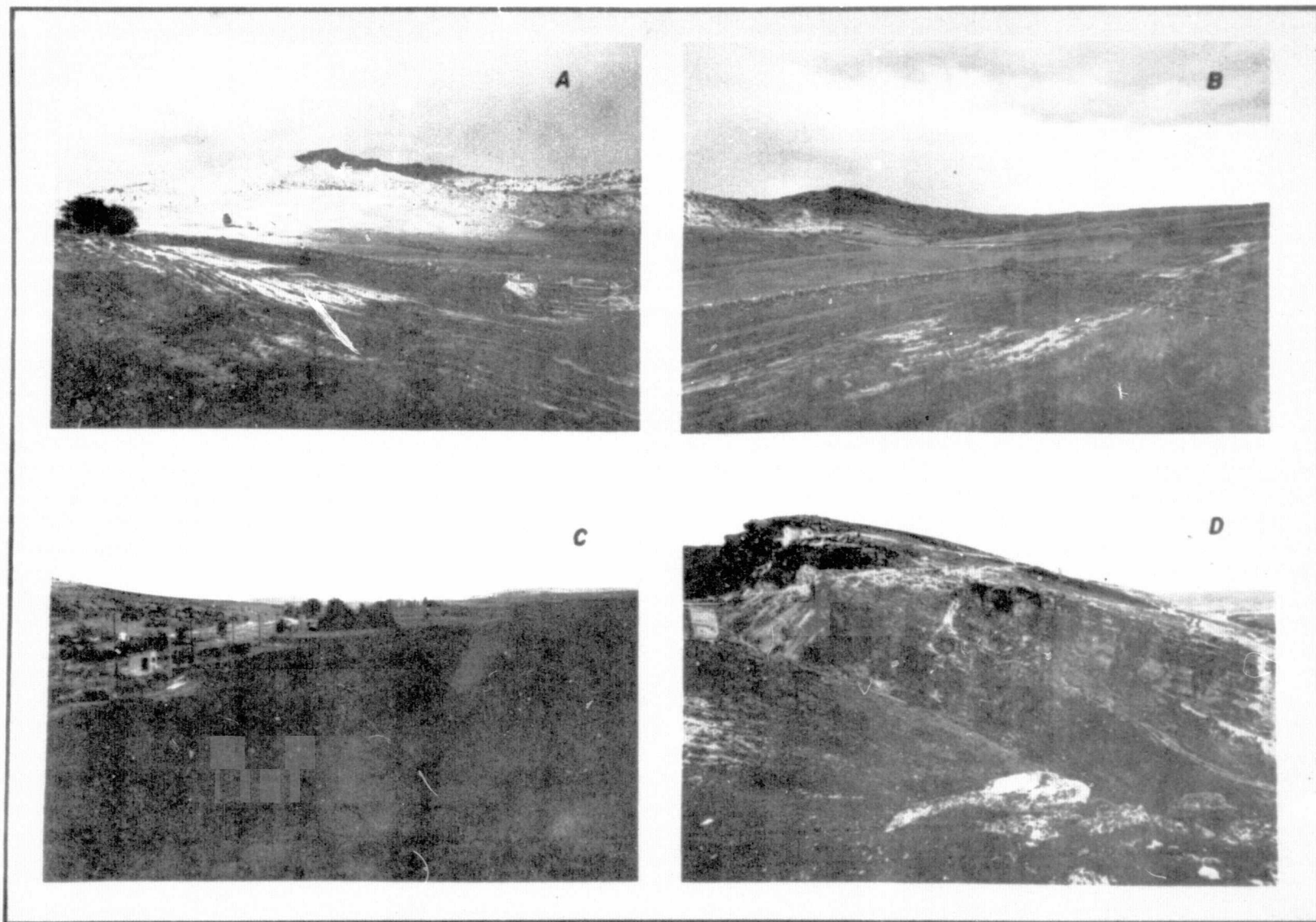


FIG. 4

Its tectonic significance should also, without a doubt, call attention to the stability of determined constructions which are made in this zone since it is possible to think of a recent activation as shown in the adjustment of certain streams to the lines imposed by this structure.

Circular structures of these dimensions are not very common, except in dominant volcanic regions.

Nevertheless annular complexes of magmatic origin can be cited with these dimensions in the Central Sahara (BLACK et al. 1967) situated on a craton and which would give way to a subsident cauldron. In our case, nevertheless, the post-paleozoic deposits do not reflect this conditioning and particularly the Miocene (post-orogenic) does not reflect this possible subsidence (MARTIN ESCORZA, 1976; MARTIN GARCIA & LEYVA CABELLO, 1973).

The images obtained by LANDSAT-1 also have shown the existence of the curved and straight lines in the Adirondack Mountains (New York) whose origin is believed to be due to a large dome developed in the rocks of Proterozoic and Paleozoic, with recent activation due to a glacio-isostatic mechanism (ISACHSEN, 1975). We cannot invoke this mechanism with certainty, in our case, because a glaciation of this importance is not known in these regions during the Quaternary nor in periods before that, but it is evident that this same area shows that it has a relative minimum in the map of anomalies of gravity which was obtained by the Hawaii Institute of Geophysics, 1966.

Annular circular structures of this type are also found in the subsident crater which because of the decompression are formed in first moments after a subterranean atomic explosion (in BOLT, 1976, fig. 3.3). However, these structures have smaller dimensions than those detected by us.

The observation by means of the LANDSAT-1 images, has recently permitted differentiating a large elliptic structure

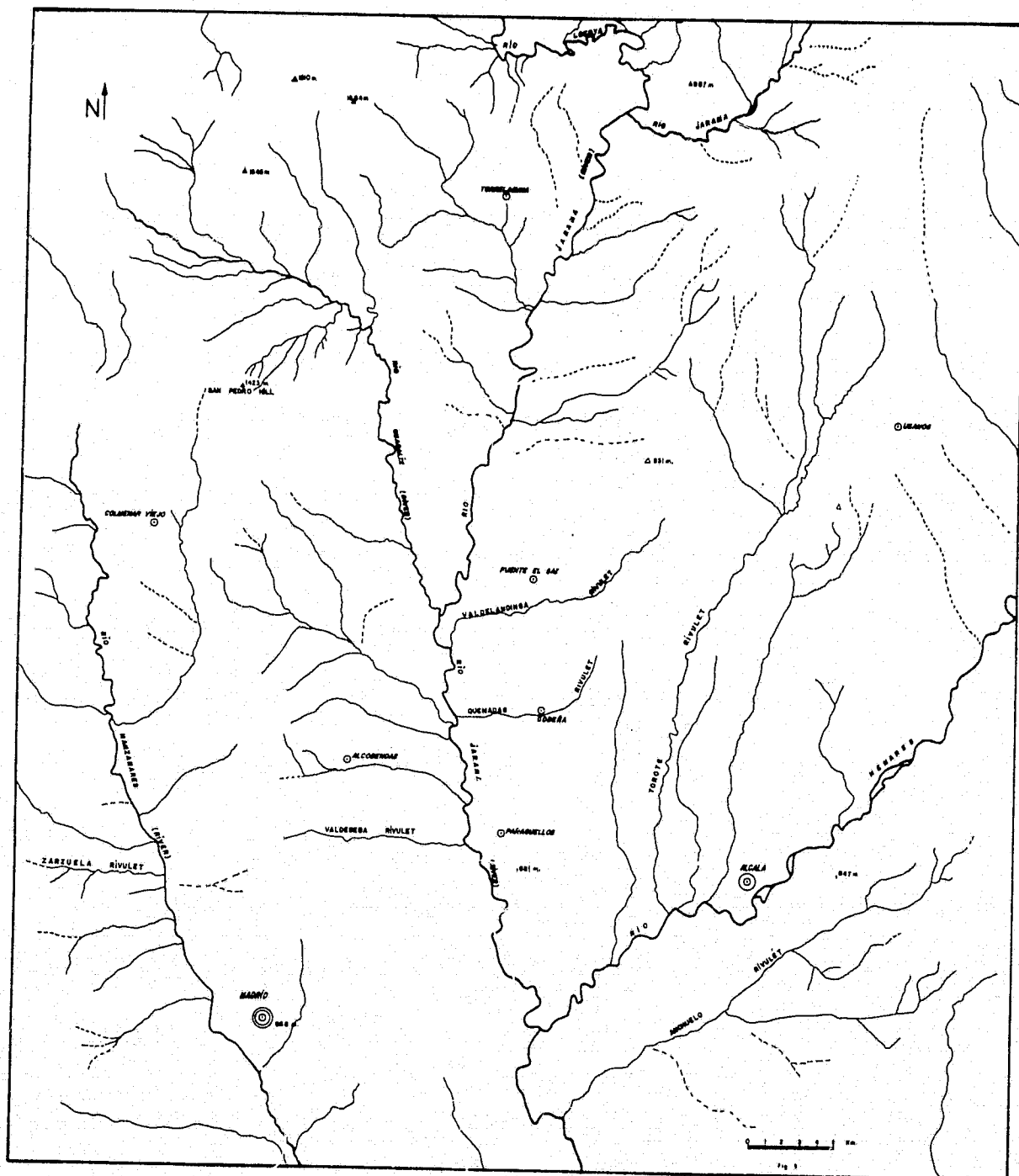
in the center of the Iberian Plateau called the Castillian-Extremeñan Arch (ALIA, 1976). This megastructure can have implications on a cortical scale and denotes that it has experimented a cave-in phase after a previous elevation phase (op.cit). Precisely, our "Structural halo of Guadalix" could be a phenomenon due to this cave-in phase which would induce restricted areas to decompression similar to those which on a smaller scale are developed by nuclear explosions and which we have mentioned above. The interference with other tectonic directions parallel to the large axis of the "Castillian-Extremeñan Arch" which has a NE-SW direction, would not permit the development toward the North of the circular lines we are considering. This line is concretely in the contact zone between the basement of the Central System and the small voussoir of the San Pedro landmass which is surrounded by Cretaceous and Paleogenic sediments. This cave-in could have furthermore been favored by or used by pre-existent post hercynian structures. Nevertheless, in later works we shall try to define these preliminary ideas which undoubtedly lack a firm support of geological and geophysical data.

#### CONCLUSIONS.

- 1 - By means of the most recent LANDSAT images supplied by NASA, we have been able to detect an annular tectonic structure to the North of Madrid which we have named "Structural halo of Guadalix" since its center is situated in the locality of Guadalix de la Sierra.
- 2 - This circular complex has from 30 to 40 km. of radius and its influences at its most extreme edges reach the capital city of Madrid.

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- 3 - Its origin could be related to the cave-in phase which took place after the elevation of the "Castillian-Extremeñan Arch" during the Alpine period (ALIA, 1976), which is the dominant megastructure in the Iberian Plateau, and one of whose smallest components would be our "Structural halo of Guadalix".



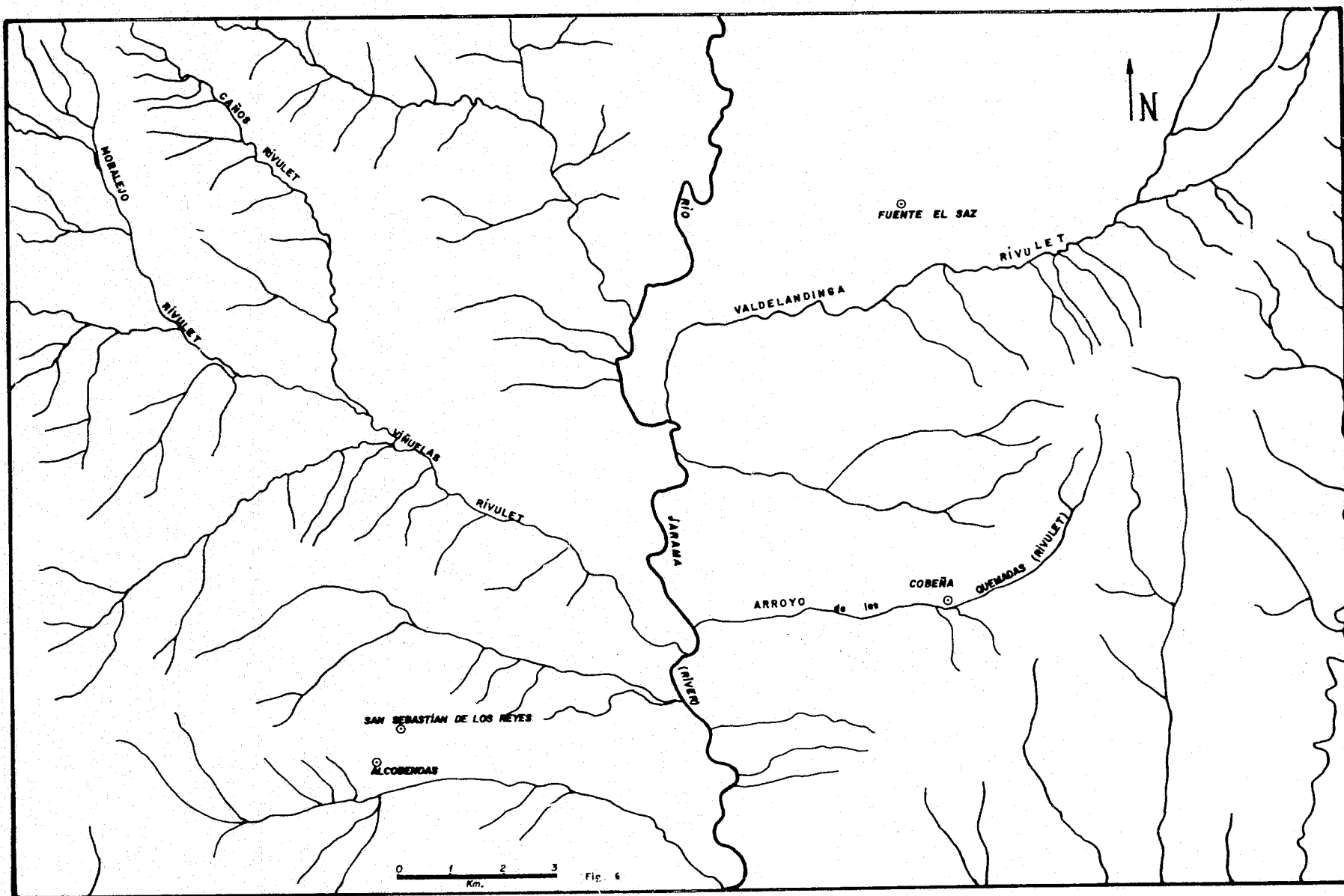


Figure 1.- Geological diagram of the area studied. The data has been collected from: FUSTER & FEBREL, 1959; DE LA CONCHA, 1962, 1963; BABIN VICH, 1971, Bol. Real Soc. Esp. Hist. Nat. 69,5-27; APARICIO, A. & CASQUET, C. & BARRERA, J.L., 1973, Estud. Geol. 29,479-487; HERNANDEZ-PACHECO, F., 1965. Bol.Real.Soc.Esp.Hist. Nat., 63,5-16; MARTIN ESCORZA, 1976; FEBREL, T. & FUSTER, J.M. & DE PEDRO, 1958, Inst.Geol.Min.España; APARICIO, A & BARRETA, J.L. & CARABALLO, J.M. & PEINADO, M. & TINAO, J.M., 1975, Mem. Inst. Geol. Min. España, T.88

Figure 2.- Studied section of LANDSAT IMAGE E-2367-10122-7, and whose situation is illustrated in the small figure in the bottom left hand side. (M=Madrid).

Figure 3.- Structural lines obtained from the observation of the zone represented in Figure 2. The result is an annular structural complex of concentric lines which we have called "Structural halo of Guadalix".

Figure 4.- (A) The landmass of Cerro San Pedro, where directly in the field differences in the land cultivation of the erosion point out the corresponding lines of the circular structure of the Structural halo of Guadalix. (B) These same lines are prolonged toward the piedmont zones making small valleys encased in the glassy materials. (C) The Quemadas stream, near Cobena, curving itself toward the NE. (D) The Cretaceous limestones constitute a structure in NE-SW direction (dipping down in this case toward the SE) which has no relation with the circular structure detected in this work.

Figure 5.- Fluvial network of the zone obtained from a topographical map of 1/100.000 scale. As can be observed, only the secondary network is that which in some cases defines the curved limitations corresponding to the Structural halo of Guadalix.

Figure 6.- With much greater clarity than in figure 5, we can see that effectively the secondary network obtained from the 1/50.000 scale map sharply marks curved linear directions which unmistakeably draw the circular structure we are dealing with in this work.

#### IV. PUBLICATIONS

The Remote Sensing Newsletter (Boletín de Teledetección) continues being published semimonthly in spanish language free of charge, covering items of national interest on remote sensing.

#### V. PROBLEMS

\* Instituto Geográfico y Catastral purchased last year a spectroradiometer Spectral Data model, covering the visible and near IR (400 - 1100 nm), which is currently being installed on a truck as movable unit of radiometry and field laboratory of remote sensing. It was intended that this equipment operated for the development of this project, obtaining percent directional reflectance curves of objectives in narrow bandpasses; but because the long delay on delivery no data have been obtained at the moment in the field. The equipment is now operating in laboratory and will be used in the next future for selecting the spectral characteristics of the required narrow bandpass filters for planning multiband aerial photography missions.

\* Some field work was done in the test site of Aranjuez (as announced in the Second Quarterly Report), coinciding the observations with a multispectral flight carried out by the INTA (Instituto Nacional de Técnica Aeroespacial) in collaboration with the french CNES (Centre National d'Etudes Spatiales) during the month of May. The plain was a CASA-212 equiped with four Hasselblad cameras and a 10 channels scanner Daedalus (without thermal IR channel). Flying height was 500 m. Although images have been processed by INTA, the tapes of the scanner had to be forwarded to the CNES in Toulouse (France) for visualization.



Until the date of submission of this report none data (image or tape) has been provided to any of the participant, organizations in this project for photointerpretation or analysis. Furthermore, the CNES is going to visualize only the recorded channel number 9 (0,80 to 0,89  $\mu$ ) but not the others. As result of this situation, unless data are provided in the next few days to any of the participant organizations in this project, results of this aerial mission and correlation of data with ground truth and LANDSAT imagery will not be provided in the Final Report.

\* The Italian receiving station of Telespazio was supposed to provide images over Spain for the purpose of this project. At the moment no material has been received and such data, when arriving (if they do), will not be submitted for the Final Report. Existing NASA supplied images are enough for a good accomplishment of the established objectives in this project.

## VI. DATA QUALITY AND DELIVERY

All images supplied by NASA through EROS Data Center are satisfactory, with a very low cloud coverage and of good quality.

Five MSS tapes were requested and received from EROS Data Center, corresponding to selected images of good quality and different dates over Central Spain.

Delivery of all material provided by NASA was done in a fast way through the local contact - Air Attachee to the Spanish Embassy in Washington, CONIE (Comisión Nacional de Investigación del Espacio) and forwarded immediately to the Principal Investigator.

Concerning the local contact required with Telespazio, the Air Attachee to the Spanish Embassy in Italy was in charge

of receiving the data, to be forwarded to CONIE and, from that point, to the Principal Investigator. Personal contact has been maintained between our local representative in Rome and Telespazio for a fast delivery of the products, but Telespazio requested an agreement with CONIE before supplying images. Until the moment none agreement is envisaged between CONIE and the Italian receiving station concerning this project.

#### VII. RECOMMEDATIONS

From the point of view of spanish investigators no practical changes should be done in operations, and as NASA is concerned all data supplied were satisfactory.

#### VIII. CONCLUSIONS

The Final Report of this project will be submitted dated September 5, 1976 to NASA. This represents that in a few time this research will be finished. But before considering new areas of interest or application for the multidisciplinary working group involved here, it must be taken into account that one year ago LANDSAT was an unknown for many spanish investigators. And the change produced in the last months allows contemplating new operational modes of processing LANDSAT information in many scientific fields. From a first step in this project, which could be defined as "examination" of the data, a new way of work is being introduced at the Universities, Government organizations, private companies, etc. Items of application today include such conflicting aspects as pollution, energy, water resources location, mineral research, crop inventory, fire detection, etc.

For developing this project a group of investigators worked together and LANDSAT made consistent such group. As a common objective to look at, LANDSAT data provided once more its look of the Earth from the space, which is an excellent point of view for obtaining a synoptic view of the humans and their background.

This project has developed a strong methodology of work for the future and, even if LANDSAT was not needed, it is tranquilizer to recognize it as a custodian of the planet at 925 kms height.

Announcement of detailed economic, social and technical conclusions will be done in the Final Report.